



Broadband Inflight Connectivity based on Air-to-Ground

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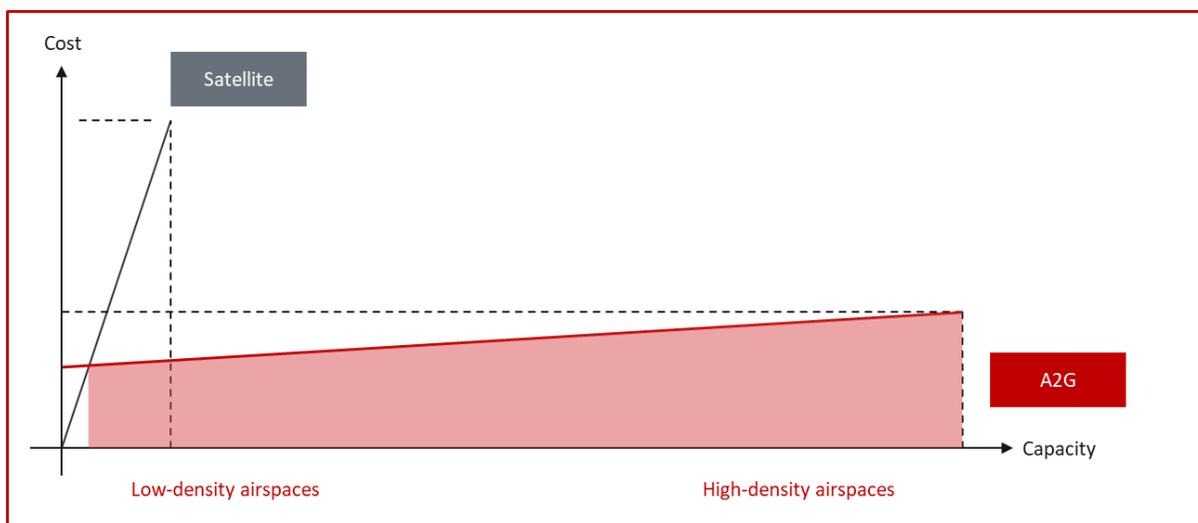
The digital sky requires true broadband connectivity

The use cases for Inflight Connectivity are manifold. Market research suggests that 90% of passengers would like to connect, but less than 10% do so, as fees are high, and performance is poor. Flight crews could optimize their flight path based on real time weather updates. Aircraft systems could report the need for maintenance and trigger ground crews accordingly, so that ground times can be minimized, and resources be used most efficiently. In the cabin, online credit card verification would eliminate fraud, and qualified medical assistance from the ground would avoid unnecessary diversions.

The ever-increasing demand for Inflight Connectivity is driven by several factors: the continued growth of airline passenger traffic, which is expected to double by 2035; the vast majority of passenger availing Wi-Fi services; the amount of data generated by modern aircraft systems, which has already surpassed 1 Terabyte per 24-hours cycle; other aircraft types that require connectivity for mission accomplishment, for example, police and rescue helicopters; and finally Urban Air Mobility, with air taxis expected to mass-proliferate in the second half of the decade.

Most current Inflight Connectivity solutions are based on satellite communications. These systems are essential for providing connectivity over oceans and on sparsely flown air routes but fail to deliver the capacities required in dense airspaces at a cost point that would trigger wide adoption. Retrofitting aircraft with satellite systems is expensive for airlines, given the cost of the sophisticated equipment, structural reinforcements of the fuselage, the ground time required to install it, and the additional fuel consumed due to the drag introduced by humpback antennas. Most importantly, the monthly recurring data charges typically prohibit any business case to be positive.

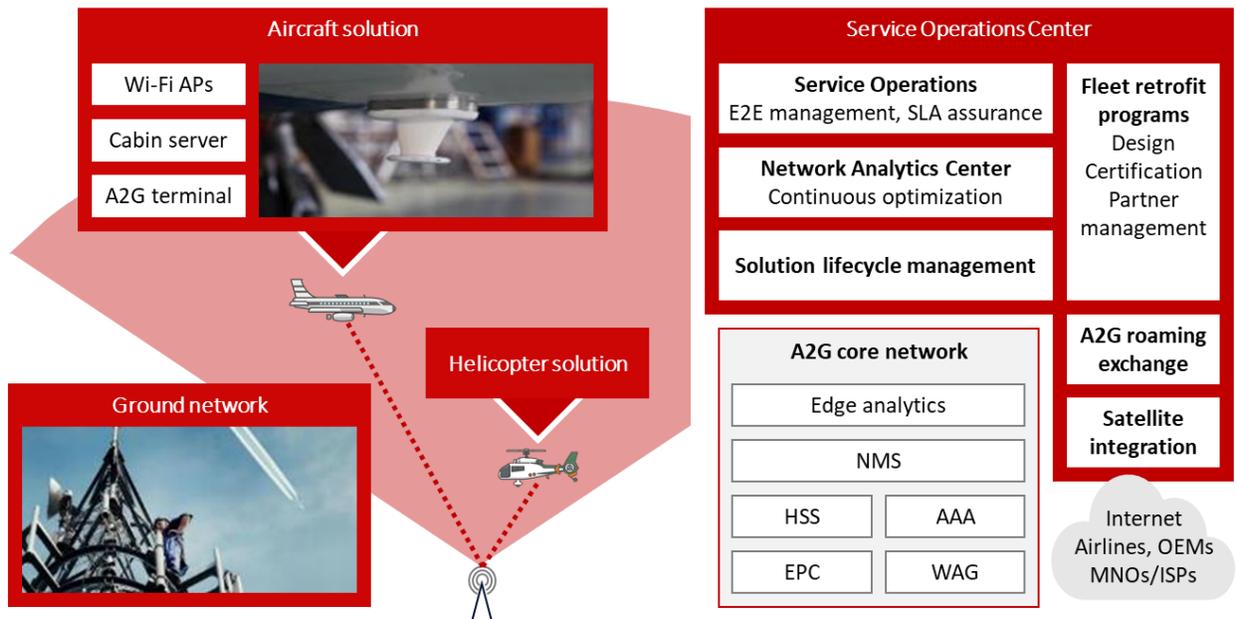
The SkyFive Air-to-Ground (A2G) solution takes a completely different approach. Built upon standard 4G and 5G network components, aircraft are connected from the ground up rather than from space, with abundant capacity delivered in busy airspaces and optionally also on the ground at airports. The solution inherently provides low latency communications, which enables an entirely new class of use cases for Inflight Connectivity, ranging from interactive cloud-based applications in the cabin, to transferring vast amounts of aircraft data to the ground in real time.



With the SkyFive A2G solution the connectivity demands of the aviation industry can be met at the lowest possible cost per bit, by using standards-based technologies with significant economies of scale from the mobile communications industry as the foundation and taking advantage of existing ground network infrastructure, such as, towers and backhaul transmission to connect these towers. Like for any cellular network, capacity can easily be added by increasing the number of cells, for example, around busy airports. As a result, the cost of Inflight Connectivity gets decoupled from the capacity, similarly to how it has been achieved with mobile services on the ground as well.

Solution overview

The SkyFive A2G solution comprises the A2G network on the ground, complete aircraft solutions for commercial aviation and public safety, and the Service Operations Center.



Ground network

The ground network consists of A2G base stations with upwards-pointing antennas optimized for airspace coverage, which create very large cells in the sky. Given that, unlike on the ground, radio signals can freely propagate, a single base station provides broadband services to aircraft flying within a 150 km range, up to speeds of 1.200 km/h. The SkyFive algorithms enable operate cellular technologies within such extreme parameters.

All base stations connect to a centralized A2G core network. There, all data traffic is managed to adhere with different Quality of Service levels. The A2G core network connects to the Wi-Fi gateway, which

terminates the passengers' Wi-Fi sessions. Passengers can establish these sessions in several ways, for example, seamlessly as a customer of a Mobile Service Provider or the airline, with voucher codes, and through a captive portal. The A2G core network also contains the secure aircraft registry and connects to other A2G networks via roaming interfaces, allowing aircraft to roam into other A2G networks and vice versa.

A2G terminal

The A2G terminal for commercial aviation consists of a baseband unit, a radio unit, and a palm-sized antenna mounted below the aircraft fuselage. The baseband unit connects to a server, from where data is distributed within the aircraft: to the cabin network, to the cockpit, and to various other aircraft systems.



Service Operations Center

The SkyFive Service Operations Center performs all functions of an Inflight Connectivity provider, including the 24/7 tasks of managing all airborne and ground components, assuring that Service Level Agreements are fulfilled, and providing real time availability and performance dashboards to airlines. The embedded Network Analytics Center continuously receives, fuses, and analyzes data from internal and external sources, and proactively provides optimization recommendations. The SkyFive backend R&D team manages the hardware and software lifecycle of the complete solution and thoroughly validates

functionality and performance before applying any change to the aircraft. Finally, the airline program management organization leads fleet retrofits in an efficient manner, including support for aircraft solution design and certification, on site installation support, and parts logistics.

Benefits

The SkyFive A2G solution provides benefits to all participants in the Inflight Connectivity ecosystem:

Airlines

- Broadband connectivity for the entire widebody and single-aisle fleet, also including smaller aircraft types like regional jets and turboprops
- Improved operations efficiency and associated cost savings from streamlined flight operations, inflight diagnostics, and predictive maintenance
- Affordable or free Internet as a differentiator, plus various options for generating ancillary revenue through e-commerce and advertisements, based on most passengers being online
- Increased productivity for business travelers by virtue of video conferencing, online collaboration, and efficient use of cloud-based applications
- Digital implementation of COVID-19 safety protocols, including touchless purchases, inflight disruption handling, and seamless transfer to prebooked ground transportation
- Flat data charges applied by the Inflight Connectivity provider, which enable unlimited data consumption by passengers, crew, and aircraft systems
- Minimum variable cost from incremental fuel burn and maintenance, due to the very low weight, negligible drag, and low technical complexity of the A2G terminal
- Quick aircraft modification in less than 8 hours, for a complete nose-to-tail retrofit of an aircraft that was entirely unconnected before

Public safety

- Enhanced effectiveness of airborne missions through rich integrated communications between airborne assets, ground teams, and command center
- Reliable sky coverage from a dedicated aerial network that provides its full capacity to aircraft and is completely decoupled from public cellular networks
- Private communications within an entirely independent network, secured with state-of-the-art ciphering and encryption mechanisms
- High performance connectivity for bandwidth-hungry and low latency applications, enables live streaming and real time analysis of airborne sensor data on the ground
- Minimum investment and operational cost by virtue of a special A2G terminal for helicopters and unpressurized aircraft and flat data charges applied by the Inflight Connectivity provider

Mobile Service Providers

- Opportunity to enter the Inflight Connectivity market with a proposition that radically boosts performance, cuts costs for airlines, and streamlines the value chain
- New consumer revenues in the largely underserved airline passenger market, plus various upsides from premium content, advertisements, mobile payments, and various partner services
- Increased brand value and loyalty by serving subscribers during their entire journey, brand exposure to incoming roamers already when boarding the aircraft in their home countries
- Low capital investment and recurring operational costs due to very large cells resulting in only a few towers, reuse of ground infrastructure, and optimized work split with SkyFive
- Assured solution evolution and scalability at minimum cost, resulting from using of standards-based 4G and 5G technologies and leveraging their economies of scale

Connected: the skies of Europe

Europe has one of the most congested skies in the world, with more than one billion passengers and 11 million flights per year. The European Aviation Network (EAN) – a partnership of Inmarsat as the Inflight Connectivity provider and Deutsche Telekom as the A2G network operator – is in commercial operation today and covers the airspace over 35 European countries. With up to 100 Mbps delivered to each aircraft, EAN proves the overall viability of connecting aircraft from the ground, and the performance of the A2G solution, which is based on the technology and implementation work of SkyFive. To date, already hundreds of aircraft have been retrofitted with the A2G terminal, and passengers are enjoying a truly broadband Wi-Fi experience.

Conclusion

The SkyFive A2G solution delivers true broadband services to airlines, business jet operators, public safety authorities, and providers of Urban Air Mobility. Its capacity caters for the busiest airspaces, and scales to meet the growth of the airline passenger market, the connectivity requirements of increasingly connected aircraft and avionics systems, and future critical communication needs of air taxis. Using standard 3GPP technologies as the foundation assures the solution is future-proof and can be operated at the lowest cost per bit. Airlines can utilize it as the sole connectivity solution, for aircraft flying on domestic and continental routes, or in combination with existing satellite systems, for aircraft flying on long haul routes that include segments where A2G coverage is not available (yet).

COVID-19 has been an unprecedented shock to the airline industry, but also acts as an accelerator of overdue airline digitization, for which true broadband connectivity in the sky is a key enabler. Operational efficiency, ancillary revenue generation, and a safe travel experience are critical objectives for airline to recover quickly. The SkyFive A2G solution is an ideal fit to the post-pandemic commercial aviation world of smaller aircraft, emphasis on domestic and continental routes, constrained balance sheets, and the need for touchless journeys without queuing. Together with its Mobile Service Provider partners, SkyFive is committed to connect the skies and create significantly value for a large ecosystem.